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*In cooperation with*

State Agricultural
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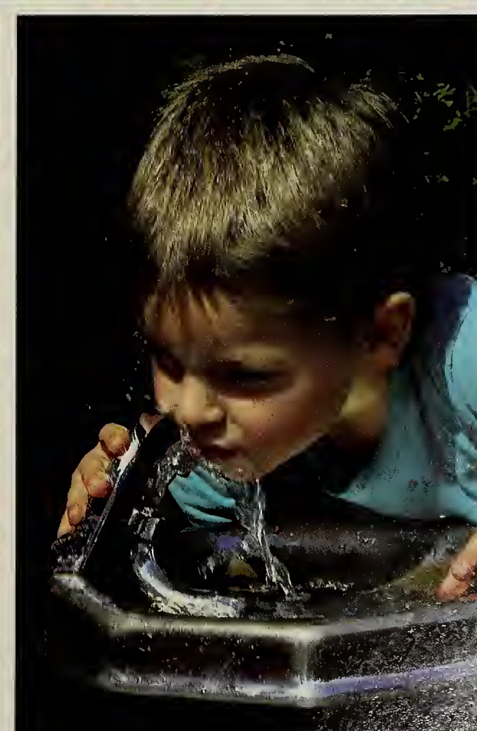
# USDA Research Plan for Water Quality



# Foreword



Advances in agricultural science and technology during this century have profoundly affected our standard of living and way of life. Agricultural chemicals contribute substantially to the productivity and efficiency of agriculture, and their many benefits to the well-being of rural and urban communities throughout the world are recognized and accepted. Even so, concerns about the possible risks to human health, water quality, and a safe environment resulting from a perceived overdependence on these chemicals are being expressed by a broad segment of our community. Better methods for detecting the presence of chemicals at trace levels in surface waters and groundwaters have alerted us to the need to be more judicious in their use and more careful in their management. The U.S. Department of Agriculture is committed to ensuring that this Nation meets the challenge of maintaining the efficiency and productivity of agriculture without compromising the quality of our water resources and the safety of our environment.

This departmental research plan establishes the goals, objectives, and implementation strategy for developing the science and technology needed to maintain and enhance the quality of our Nation's water resources. The need for a major research effort on the full spectrum of water quality problems resulting from agricultural and silvicultural activities is recognized. However, because groundwater is the primary source of drinking water for nearly 90 percent of our rural population and more than 50 percent of our total population, the plan emphasizes improved chemical use and management for protecting groundwater quality. The research will be conducted in cooperation with other Federal agencies with missions and responsibilities for water quality protection. The plan was developed jointly by the Agricultural Research Service and the Cooperative State Research Service, with major contributions from professionals of the State agricultural experiment stations and from other agencies of the Department, including the Agricultural Stabilization and Conservation Service, Economic Research Service, Extension Service, and Soil Conservation Service.

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## Executive Summary

Widespread public concern exists that agricultural and forestry activities are contributing to the contamination of the Nation's surface waters and groundwaters. The U.S. Department of Agriculture and State institutions have some excellent research programs that address this concern. The Department now proposes a plan for integrating and expanding these programs to emphasize groundwater research. The plan does not include all the groundwater concerns of the Department but, rather, focuses on the impacts of pesticide and fertilizer use on groundwater quality. The surveys of groundwater quality that have been conducted show small quantities of pesticides and nitrate in some wells. However, the data are inconsistent, and the inconsistencies, for the most part, lack an adequate explanation. The insufficiency of and inconsistencies in available data make it difficult to know how serious the problem is, how widespread it is, and how it should be solved.

The new research plan proposed by the Department calls for a broad partnership with other Federal agencies and State institutions to fill key information and technology gaps in groundwater quality assessment and management. The goals are to determine the seriousness and extent of the groundwater quality problem, improve our understanding of the processes that control chemical leaching, and provide timely and cost-effective remedies for problems that exist.

A major research effort is planned to improve our understanding of the processes that determine agricultural productivity, and the fate and transport of agricultural chemicals. This understanding is essential to the development of new and improved components of economically viable and environmentally safe crop production systems. It will also facilitate the adaptation of field-tested production systems to changes in soil, crop, and climatic conditions. This research will enhance and expand the research already underway in State and Federal laboratories. Significant advances are projected in assessment technologies, sampling and analytical methods, onfarm waste disposal practices, and the development of innovative soil, water, and chemical management practices.

A Midwest Initiative is also planned to assess the severity and extent of the groundwater quality problem in selected corn and soybean production areas of several Midwestern States and to demonstrate a systems approach to problem solving. The assessment strategy will be based on the use of intensively instrumented sites that represent the diversity of soil, geologic, and climatic conditions found in the Corn Belt. A systems approach will be used to determine the combinations of production practices that best satisfy the economic, environmental, and social needs of the region. Emphasis will be placed on corn and soybean production systems that are suitable for use on croplands overlying the major aquifers of the region. Management support systems will be developed to help farmers and others select the practices that improve both farm profitability and groundwater quality. The proposed systems approach will permit the transfer of results to conditions not included in the field program and to areas other than the experimental sites.

A similar systems approach will be used to identify the optimum combinations of crop production practices for other physiographic regions of the country with vulnerability to groundwater contamination by agricultural chemicals. Regions of major concern include those with intensive dryland and irrigated farming, concentrated livestock production, high recharge rates, and shallow groundwaters. Emphasis will be placed on intensively managed croplands overlying aquifers that are important to rural development or that supply the drinking water needs of a large number of people.

Results of this plan will provide definitive answers to many of the questions being asked. Public fears will have been addressed. Whether or not there is a basis for these fears, best management practices will be identified and/or developed so that the leaching of pesticides, nitrate, and other potentially hazardous chemicals can be minimized and managed. Practical, inexpensive pesticide waste disposal systems will be tested for onfarm use. Regardless of the severity and extensiveness of the current problem, major environmental and economic benefits to future generations can be expected.

## Introduction

The Nation's surface waters and groundwaters are being adversely impacted by human activities. Potential water contaminants include sediments, salts, toxic trace elements, animal and human wastes, and agricultural and industrial chemicals. Most of the major surface water quality problems, including the offsite damage from agricultural and forestry practices, have received considerable attention from the research community. While substantial progress has been made in solving some of the water quality problems associated with crop, livestock, and timber production, much more work remains to be done.

A problem that has attracted considerable interest in this decade is the intrusion into groundwater of agricultural chemicals applied to soils and crops. Groundwater quality surveys conducted during this period have detected trace amounts of nitrate and selected pesticides in certain aquifers. The significance of the findings remains inconclusive and controversial because many of these chemicals are detected at very low concentrations, their toxicological effects are not clearly established, and much of the data are of unknown quality.

Nevertheless, public apprehension continues to increase as more attention is focused on the possible health effects associated with some of these chemical residues. These public concerns are increasing the pressures for new environmental legislation and regulations on chemical use and disposal at local, State, and Federal levels. The implications for U.S. agriculture and the future well-being of the farm community could be serious.

The U.S. Department of Agriculture (USDA) is concerned about the health of our rural population, environmental quality, farm profitability, and user liability, even though it has not been possible to assess definitively the significance of the concentrations of chemicals that have been reported. In response to these concerns about chemical residues in groundwater, the USDA now proposes a major Federal and State collaborative plan to determine the magnitude and scope of the groundwater quality problem, and to develop resource management strategies for minimizing any contribution from agriculture to the problem.

## Justification

It is increasingly recognized at State and Federal levels that agricultural research must give more attention to developing methods for assessing and controlling, where appropriate, the environmental consequences of changes in farming and forestry practices. For more than two decades, the public has been concerned about the potential threat that agricultural and other chemicals will enter and degrade the quality of surface waters. This concern led to the enactment of major Federal legislation to protect surface water quality. In turn, the legislation triggered a nationwide effort, involving all levels of government, to evaluate the severity of the problem, develop cost-effective solutions, and regulate the use and disposal of potentially harmful chemicals.

Until recently, there was less concern in the general population and the scientific community about the potential for agricultural chemicals to contaminate groundwater. This lack of broad concern was based on an intuitive acceptance that several feet of soil provides an effective natural filter or reaction zone for removing potentially damaging chemicals. While the filtering effect of the soil is adequate for many chemicals, recent experimental evidence suggests that at least for some soils and chemicals, the soil filter is less efficient than had been assumed. This evidence has, in turn, raised questions regarding the environmental costs of farming practices such as conservation tillage, fall fertilization, chemical control of weeds, and chemigation and fertigation (the application of pesticides and fertilizers, respectively, with irrigation water). Research is needed to answer these questions and to provide solutions to any problems that exist. This research must recognize the intimate relationship between surface water and groundwater.

The potential for groundwater contamination by agricultural chemicals is high in many of the major crop and livestock producing areas of the country (see map). Factors that increase aquifer vulnerability include intensive cropping, high levels of fertilizer and pesticide use, poor water management, permeable soils and subsoils, and shallow water tables. Limited research in these areas indicates that the adverse impacts on groundwater quality of some current agricultural production practices may be significant. An expanded research effort is needed to determine the areal extent and severity of these impacts. Where major problems exist, additional research will be needed to develop and evaluate new practices that adequately protect groundwater quality.

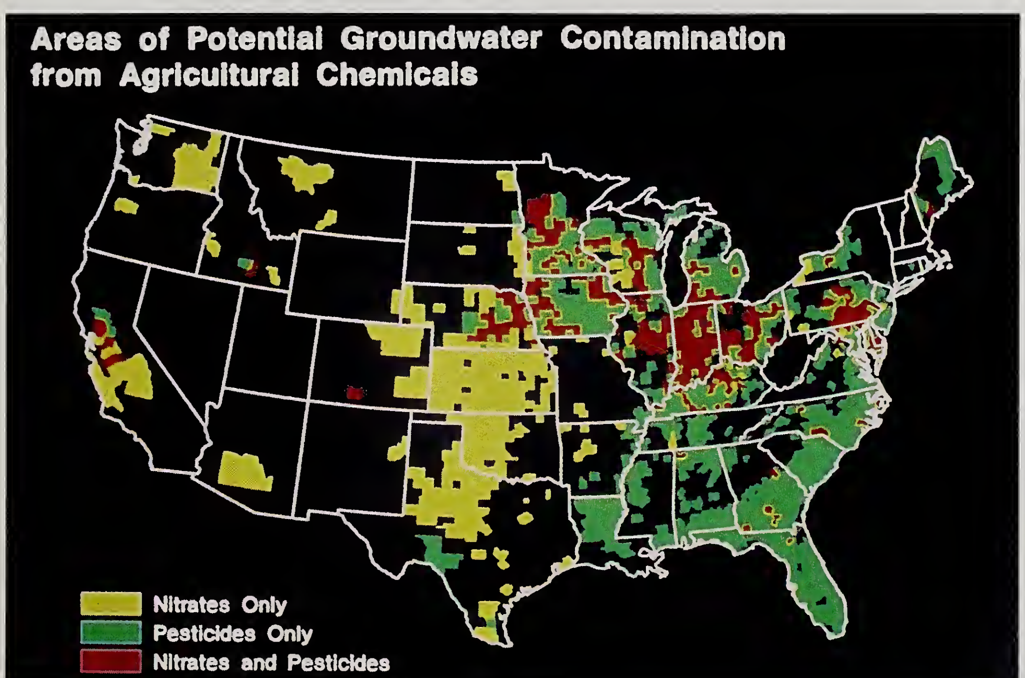
Two critical short-term needs are accurate assessment and cost-effective reduction of the overall contribution of agriculture to groundwater contamination. Meeting these needs will require an expanded research program to identify the separate contributions of a large number of farming practices within a broad range of crop and livestock production systems. Some of these practices and their associated systems are of local concern; others are of regional or national relevance.

New and existing practices that are considered beneficial to the environment include conservation tillage; targeted, low-volume pesticide applications; banded or reduced fertilization; improved nitrogen management through more effective crop rotations; improved water management; integrated pest management; and increased use of soil and plant analyses as a basis for improving the accuracy of fertilizer recommendations. However, the effects of these practices and their adaptability for practical and profitable use are often site specific. They vary with soil type, geology, climate, and cropping system and are affected by economic, social, and political considerations.

A major national concern is the effect on groundwater quality of USDA decisions that promote the use of conservation tillage. During the past two decades, many farmers adopted some form of conservation tillage, replacing conventional moldboard plowing with practices such as ridge tillage, minimum tillage, or no tillage. Initially, these practices require an increased use of agricultural chemicals, particularly herbicides to control weeds that in the past had been partially controlled by conventional tillage practices. Nationwide, the planted acreage in conservation tillage increased from 2 percent in 1968 to 31 percent in 1987. The compliance provisions of the Food Security Act of 1985 are expected to accelerate the adoption of conservation farming practices. While these practices effectively control soil erosion and may provide economic benefits, the implications of their expanded use on pesticide and fertilizer residues in the soil and on groundwater quality are largely unknown.

Without a substantial improvement in our knowledge of the effects of conservation tillage on chemical use, groundwater recharge rates, pest control, and farm profitability, it will not be possible to respond effectively to the concerns of those who feel that USDA's conservation tillage initiatives are exacerbating the groundwater quality problem. Proponents of conservation tillage are convinced that farming systems can be developed that will decrease the loss of agricultural chemicals to groundwater and also reduce contaminant levels resulting from past farming practices.

Some excellent research programs on water quality are already underway in most States and are being conducted by the Agricultural Research Service, Cooperative State Research Service, State agricultural experiment stations,




Potential areas of groundwater contamination from pesticides and nitrate. (Source: Nielsen and Lee 1987).

and the land-grant universities. A few of the programs on groundwater quality are being conducted on a multi-State or regional basis. The expansion, integration, and coordination of these programs according to a single plan with national goals and objectives are a high priority need. The USDA Research Plan for Water Quality is such a plan. It will expedite the development and evaluation of agricultural production practices that protect groundwater quality and adapt readily to local soil, climatic, cropping, and socioeconomic conditions. The applied research programs will benefit materially from current and new knowledge on the source, transport, and fate of agricultural chemicals in the soil, underlying parent material, and groundwater.

## Goals

The general goal of the USDA plan is to safeguard and enhance the quality of the Nation's surface waters and groundwaters in the presence of sustained agricultural activities. Emphasis will be placed on groundwater quality.

The specific goals of the plan reflect this emphasis and are

1. To assess the seriousness and extent of agriculture's impact on groundwater quality.

2. To develop new and improved agricultural systems that are cost effective and enhance groundwater quality.

## Objectives

The following objectives are designed to meet the general and specific goals on groundwater quality:

1. Document the sources and amounts of potentially hazardous contaminants in groundwater which are attributable to current agricultural and forestry practices, and identify the basic processes involved in their movement through soil and into groundwater.

2. Develop new field and laboratory methods for rapidly, reliably, and inexpensively analyzing pesticide residues and for determining the rates at which water and chemicals move through soils to groundwater.

3. Develop new and modified crop and livestock production systems that substantially decrease the movement of potentially hazardous chemicals into groundwater, and determine the effects of these new systems on farm costs, changes in farm inputs, and production choices.

4. Develop simple, inexpensive, onfarm methods for disposing of pesticide containers and other hazardous wastes without contaminating groundwater.

5. Develop decision-aid systems that may be used by technical and farm management specialists, Extension agents, and farm consultants to help individual farmers select, apply, and manage profitable and environmentally sound crop and livestock production practices.

6. Evaluate the economic, social, and political impacts of alternative crop and livestock production systems, policies, and institutional strategies to control groundwater contamination.

## Elements of the USDA Plan

The USDA plan comprises two elements: I. Priority Component Information and II. Selected Geographic Systems.

The Priority Component Information element consists of conducting research to obtain information on the basic physical, chemical, and biological processes that determine the movement of contaminants through soil into groundwater; to develop new and improved crop, soil, and water management components of cropping systems; and to identify the climatic, soil, and hydrogeologic variables that affect the economic and environmental responses of agricultural ecosystems.

Currently, a significant amount of relevant research is being conducted by State and Federal scientists in most areas of the United States. This work must be continued to meet the information needs of the diverse physiographic regions of the country. As envisaged, this element of the plan will enhance current research and support new thrusts identified as critical for maintaining a competitive agriculture in areas where the risks of groundwater contamination are high.

The Selected Geographic Systems element consists of obtaining all the priority component information for selected geographic areas and providing those areas with specific options for managing soils, crops, chemicals, and water to maintain farm profitability and enhance soil and water quality. The Midwest, or Corn Belt, has been selected as the first area for work of this kind. The Midwest initiative will be a major research effort and is expected to demonstrate the soundness and effectiveness of the systems approach to solving problems of groundwater contamination common to a wide area. Work will focus on the development of economically and environmentally sound corn and soybean production systems; and it will be conducted in collaboration with other State and Federal agencies, including the Geological Survey and the Environmental Protection Agency.

## I. Priority Component Information

The priority components of information are discussed according to the sequence of objectives needed to meet the goals of the USDA plan.

### Site Selection, Sampling, and Analytical Methodologies

Initially, priority will be given to solving the problems of sampling, sample integrity, and analytical methodology. A significant body of information shows that spatial and temporal changes in the concentrations of some contaminants in groundwater samples can be substantial. Measured concentrations may vary by an order of magnitude or more. The reasons for this variability in water quality will be given particular attention. Solving these problems will help ensure that the most cost-effective and well-designed protocols will be used throughout all phases of the research, and that action and regulatory agencies will have access to efficient monitoring procedures.

Improved sampling methodologies will provide the means to obtain accurate and representative data at a substantially reduced cost. Thus, they will meet a critical and widespread need by research, action, and regulatory agencies. The tools to be developed will include in situ and low-cost pesticide analytical methods, leachate and groundwater recharge measurement and sampling methods, and sampling strategies that accurately determine spatial and temporal variabilities.


Knowing where and when to sample is important.

The in situ and low-cost methods of pesticide residue analysis to be developed will include promising optical, potentiometric, and enzymatic devices that can be operated in a field laboratory or installed in a well/lysimeter. These methods will be designed to obtain continuous or high frequency data on the amounts of selected pesticide residues present. The analytical strategy will rely primarily on low-cost, efficient analyses, with detailed, highly sophisticated analyses made periodically only as a check. The present cost of nearly $100 per pesticide sample for conventional analysis imposes major limitations on the capability of most agencies to conduct comprehensive monitoring programs.

Because the spatial and temporal variabilities of soil and subsoil properties have a major influence on chemical movement, fundamental work will be undertaken to determine how to use basic soil properties, lithology, and structure in developing efficient field sampling protocols. The variabilities of other site specific characteristics, such as climate, hydrology, and geology, which also affect groundwater recharge and chemical leaching, will be defined and incorporated into simulations and interpretations. Often it is the extreme values of these characteristics, rather than their means, that control chemical leaching.

### Fate of Agricultural Chemicals

One of the priority components of information needed to understand the impact of agricultural practices on water quality is the fate of chemicals introduced into the soil/groundwater system. These chemicals are subject to physical, chemical, and biological processes that act jointly to determine their fate. Prediction of the extent and duration of groundwater contamination depends upon an adequate understanding of these dynamic processes. Although previous work has identified the general character of these processes, their effects on the fate of many of the new chemicals being introduced into the environment are as yet inadequately understood.

Consequently, further research will be undertaken to more completely define the chemical and biological degradation processes, mobility and leaching processes, and volatilization and plant uptake processes for these agricultural chemicals. Because of the increased use of high residue farming, emphasis will be placed on research to evaluate the effects of crop residues on soil moisture and temperature profiles, nitrogen and pesticide losses, and optimum chemical requirements for plant nutrition and pest control.

Conventional pesticide analyses are accurate but complex and costly.

### New and Improved Management Practices

Mechanical, cultural, biological, manual, and chemical methods can all be used in various combinations to control the growth of weeds and prevent serious losses in crop production. An accelerated effort to develop integrated weed management systems and general pest management systems will be a major thrust of this information component. Research on controlled-release formulations of existing pesticides and the development of innovative methods of weed control will be actively pursued.

Chemigation and fertigation are effective ways to apply pesticides and fertilizers to irrigated crops. Improvements in these practices will be made to minimize the risk of excessive chemical movement below the root zone. The benefits of using advances in water management technol-

State-of-the-art pesticide disposal combines new chemistry with biotechnology.

ogy, improved irrigation practices, surface and subsurface drainage, and water table control, to improve water quality will also be assessed.

**Low-Cost Pesticide Disposal**

Improper disposal of pesticide wastes and containers poses potentially significant hazards for contamination of soils, surface water, and groundwater. A simple, inexpensive, pesticide waste-water disposal unit has been developed, and two prototypes have been built. The disposal method uses ozone to fragment the pesticide and soil microorganisms to metabolize the fragments. Improved strains of these organisms will be developed to improve the efficiency of the process. The genes associated with the metabolic process will be isolated and inserted into natural soil organisms to enhance their ability to break down pesticides in soils and contaminated waters.

**Predictive Models and Decision Aids**

Models that simulate the behavior of chemicals in the soil/ground system are becoming valuable tools for assessing the fate of potential soil and groundwater contaminants and for extrapolating the data collected at selected sites to other areas. The most detailed forms of these models are used by the research community to test their understanding of the basic physical, chemical, and biological processes operating in agricultural ecosystems. Simplified forms of these tested models are used by community managers and regulatory personnel to predict in broad terms the environmental fate of chemicals introduced into agricultural ecosystems. They

Pesticides properly applied in irrigation water will reduce groundwater pollution.

are also used to identify geographic regions, and cropping and livestock production systems which pose a potentially serious threat to groundwater. They have the potential to be used as decision aids by agricultural specialists and managers working with farmers to design and implement environmentally safe practices.

Despite the substantial progress that has been made, major improvements in accuracy, flexibility, and performance are needed. The research to be undertaken will improve the reliability of these models and decision aids by incorporating improvements in scientific understanding of the processes and components. Model flexibility will be improved by extending the capabilities of existing models to include two-dimensional and possibly three-dimensional simulations of agricultural landscapes.

Computer models identify cropping practices that seriously threaten groundwater quality.

**Economic, Social, and Political Impacts**

Groundwater contamination has economic, political, and social consequences, many of which are new to our experience. Further, the complex economic and policy setting in which contamination occurs is poorly understood. Issues to be addressed include analyses of economic and other incentives that influence individual agricultural practices in ways that lead to groundwater contamination, appraisals of the economic and social consequences of alternative agricultural policies, and more effective institutional strategies for minimizing groundwater contamination.

## II. Selected Geographic Systems

The available information on the concentrations of agricultural chemicals in groundwaters and on the comparative vulnerability of different landscapes to the leaching of chemicals indicates that a systems approach to solving the groundwater quality problem is needed for several major crop producing areas. Some examples of crop and livestock production systems that could benefit materially from a regional integration of effort by State and Federal scientists include concentrated crop and livestock production systems in the Northeast, multiple-cropping systems in the South and the Southeast, wheat production systems in the Great Plains States and Pacific Northwest, corn and soybean production systems in the Midwest, and vegetable and horticultural production systems in irrigated areas of the West. The groundwaters underlying all these areas have been identified as vulnerable to contamination by some of the fertilizers and pesticides now in use.

Developing environmentally safe crop production systems that are acceptable to the farm community for the diversity of crops grown, chemicals used, and site conditions needing attention presents a major challenge to the agricultural community. For some crop production systems, the information base needed to select an optimum combination of farming practices might be better developed as a local or State activity. Consequently, a flexible research approach is proposed that will permit the optimum use of Federal, State, and local resources to solve identified groundwater problems.

## Midwest Initiative

The Midwest has been selected as the first geographic area for which the systems approach will be used. The selection was based on the following important factors. The Midwest is one of the most extensively farmed areas of the United States, producing more than half of all U.S. corn and soybeans and using a proportional level of agricultural chemicals. Three of the leading pesticides used by the area's farmers—atrazine, alachlor, and carbofuran—have been found in trace amounts in the groundwaters of several Midwestern States. Also, the groundwaters of this area have been identified as potentially vulnerable to contamination by nitrogen as nitrate, and high rates of nitrogen fertilization are used in corn production. Finally, conservation tillage practices, with their expanded use of pesticides and fertilizers, have been widely adopted by midwestern farmers and are now used on 45 percent of their croplands. This percentage is substantially higher than the average for the Nation.

The benefits derived and the lessons learned from the Midwest Initiative are expected to have broad national relevance and significance because the approach and procedures used will be applicable to similar initiatives in other parts of the country.


Pasture and cropland in the Northeast.


Irrigated agriculture in the Southwest.


Multiple cropping in the Mississippi Delta.


Corn production in the Corn Belt.


Peanut production in the Southeast.


Wheat production in the Great Plains.

A systems approach will be needed to solve groundwater quality problems in major crop production areas.

Conservation tillage is used widely in the Corn Belt: no tillage continuous corn (upper left), no tillage corn/soybean rotations (upper right), and ridge tillage (bottom).

## Approach and Procedures

A two-stage approach is planned. The first stage will focus on an assessment of whether, the extent to which, and the range of conditions under which the agricultural chemicals applied to corn and soybean production areas reach groundwater. The second will focus on the development and evaluation of new or improved management practices that will protect groundwater from contamination by agricultural chemicals while maintaining or increasing farm profitability. Emphasis will be placed on practices particularly suitable for sensitive sites or critical conditions.

### Assessment

In the assessment stage, the aim is to determine the pesticide and nitrate losses to groundwater for given corn/soybean management practices and to obtain information on the timing and magnitude of groundwater contamination due to these losses. The pesticides to be considered will include the herbicides atrazine and alachlor and the insecticide carbofuran. Others that are widely used in the Corn Belt and have a demonstrated potential to degrade groundwater quality may also be included.

A number of assessment sites will be selected in the Corn Belt. The sites will be representative of corn and soybean production areas that overlie significant groundwater aquifers. Significant aquifers are either extensive, important to rural development, or supply the drinking water needs of large numbers of people. The types of farming systems in use, the climate, and the characteristics of the area's soils, topography, geology, and aquifers will be considered in selecting representative sites. The operational procedures used at each site will be basically the same to facilitate comparisons of data and results.

Each site will be hydrologically distinct and will approximate a farm unit of 80 to 600 acres. The site will be subdivided into a number of large-area plots, the size and number of plots to be determined by the range of local conditions and cultural practices. In laying out plots, site characteristics will be considered to avoid undesirable interplot influences on the observed chemical concentrations in the underlying groundwaters.

A number of plots will be needed to provide adequate replication of the different corn/soybean cultural treatments. One set of plots at each site will be established at the start of the project to assess and compare chemical movement to groundwater for the cultural treatments used in the vicinity of the site. To compare differences among sites, at least one of these treatments will be common to all sites and will represent a "typical" farming system used throughout the Corn Belt. Other treatments will be selected to represent the more widely used conservation tillage and cultural systems. A second set of plots may be established at each site when new or improved management practices have been identified as promising enough to warrant field evaluation. The decision on whether to proceed with the establishment of these plots will depend on the response time of the soil/groundwater system to proposed changes in the farming system.

Work in the assessment stage will require measuring the key inputs and outputs of water and chemicals for each plot and determining water and chemical transport rates, crop parameters related to growth rate, yield and quality factors, and economic costs and returns. The water and chemical balance measurements will provide the information needed to determine the rates and amounts of losses of chemicals to groundwater and their potential impact on water quality. The economic data obtained should be sufficient to establish the economic and physical relationships between agricultural production, input cost, and water quality for the Corn Belt.

The issue of transferability of information from the selected experimental sites to other corn and soybean producing areas is critical to the development and implementation of sound policies and programs for managing agricultural chemicals. Concepts and procedures will be developed and tested to facilitate the transfer of physical, biological, and economic information, and to evaluate the social, economic, and environmental consequences of national, regional, and State strategies for managing groundwater quality. The performance of the predictive models and decision aids that are developed under the Priority Component Information element of this USDA plan will be tested using real-time data acquired in these experiments.

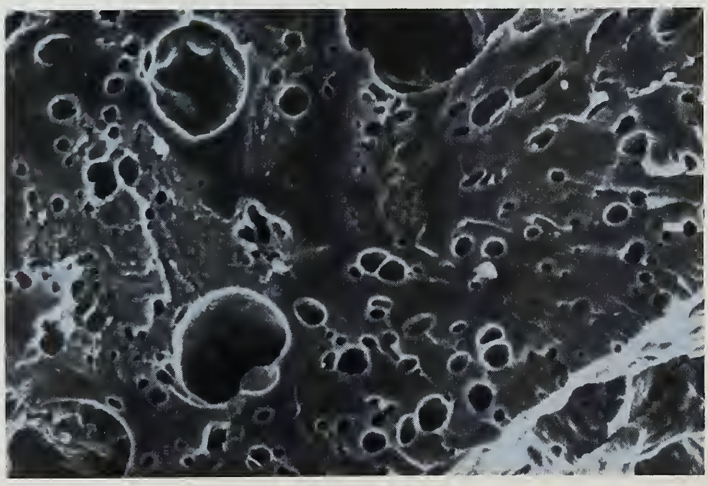
### Development of New Management Practices

Work in the second, or developmental, stage of the approach involves developing new practices or modifying major components of current practices for producing corn and soybeans, with the aim of reducing chemical losses to groundwater. New fertilizer practices may include the use of various regulators of soil and crop biology to control soil nitrate levels during periods of high leaching potential, management practices that synchronize soil nitrate availability with the nitrogen requirement of the crop, and use of winter cover crops to reduce water and nitrate levels in the soil during noncrop seasons.

A cover crop such as rye reduces residual nitrate levels during noncrop seasons.

New pesticide practices may include the use of pesticides in controlled-release carriers; low-persistence, leachable pesticides; band applications of pesticides; specified application times and rates; split applications; pesticide combinations; and combinations of chemical and non-chemical measures.

Because current pesticide waste disposal practices may be contributing to groundwater contamination, new disposal practices will be developed and tested. Also to be developed are decision aids for enabling corn and soybean producers to select farming systems that will permit them to profitably manage their farms with due attention to groundwater impacts. Finally, methodologies will be developed for analyzing the social and economic consequences of changes in farming systems and in programs and policies associated with chemical use and management.



The vesicular structure of the starch granule (highly magnified) makes starch an effective carrier for the slow release of herbicides.

### Coordination of Research on Midwest Initiative

A technical and coordinating committee will be established, and its members will consist of designated representatives of the cooperating agencies and institutions. Representation on the committee will not be limited to professionals from the target region. The committee will be responsible for developing detailed research and implementation plans, standardizing the procedures to be used where necessary, and providing direction and oversight to the project as a whole. It will have the authority to oversee the reaching of milestones and the development and release of products identified in the research plan.

Multidisciplinary research teams will be organized at several locations in the Midwest. Each team will receive specific research and development assignments from the technical and coordinating committee. Teams will be expected to devote a substantial part of their effort to meeting the stated goals of the overall project. Additionally, each team will be expected to perform project-related research of its own design. The provision for such research is intended to widen the opportunity for discovering innovative, cost-efficient ways of reducing chemical losses through leaching from corn and soybean fields. The committee may, at any time, alter the original research plan to follow up on new and promising discoveries.

A team of scientists, computer programmers, knowledge engineers, and support personnel will be established to design and implement a project data bank. Existing expertise will be used where appropriate. This team will have the important assignment of developing decision aids for corn and soybean producers. Onfarm and local economic impacts will be assessed for each cultural/management system selected for testing. The physical, chemical, biological, and economic data will be made available to Federal, State, academic, and private institutions engaged in research, chemical registration, economic analyses, and farm and resource management.

### Agency Responsibilities for Midwest Initiative

This initiative is envisioned as a major interagency cooperative project involving USDA agencies, State agencies and institutions, and other Federal agencies with missions, responsibilities, or concerns related to water quality protection. All agencies will assist with project planning, selection of sites and farming systems, and analysis and interpretation of the experimental data.

The Agricultural Research Service will be responsible for coordinating the instrumentation and data collection activities. The Cooperative State Research Service will coordinate the project related research undertaken by the State agricultural experiment stations and land-grant universities. The selection of scientists and projects will be competitive to the extent possible to maintain the integrity of the initiative. The Economic Research Service in cooperation with the State agricultural experiment stations will develop cost analyses of farm management practices and evaluations of the economic impacts of water quality management initiatives.

The Soil Conservation Service will provide general soils and landscape information and specific characteristics of soils and topography for the experimental sites. The Agricultural Stabilization and Conservation Service will provide cropping history records for project sites that have been included in a commodity reduction program. The Extension Service will be responsible for ensuring that the research sites are appropriate to serve as a regional and/or topical educational resource for training State and Federal personnel, local leaders, and other pertinent clients.

The Geological Survey and its State counterparts will be asked to provide the expertise needed for the hydrogeologic components of the initiative. The possibility of interfacing this Midwest Initiative with the Midcontinent Initiative being developed by the Geological Survey will be closely examined. The Environmental Protection Agency will be asked to augment this project with data from its planned national survey of pesticides and nitrate in well water samples and to assist with data quality assurance and sampling protocols.

## Coordination and Implementation of USDA Plan

To provide overall policy and technical guidance and to ensure coordination of the research efforts supporting the goals and objectives of the USDA plan, the following organizational structure will be used.

## National Technical Committee

A national technical committee comprising representatives of appropriate Federal agencies and cooperating State and private institutions will be established to provide guidance on policy; provide overview and approval of general guidelines on administrative and technical matters; and facilitate coordination of work by participating agencies, departments, and other institutions.

## Regional Technical and Coordinating Committees

Regional committees, patterned after the regional system of the Cooperative State Research Service, will be formed from representatives of participating agencies and institutions. They will develop priorities and organize and conduct planning and reporting conferences. These conferences will provide forums for reporting the results of research supported by new funds, as well as related but independently supported research. They will help to establish and maintain effective lines of communication, an essential requirement for a well coordinated program.

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